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1959

CHAPARRAL CONTROL PROJECT

ANNUAL REPORT - 1959

by

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UNITED STATES DEPARTMENT OF AGRICULTURE

Agricultural Research Service
Crops Research Division
Crops Protection Branch

Rocky Mountain Forest and Range Experiment Station
Arizona State University
Tempe, Arizona

1959 Annual Report

of

Weed Investigations

by

Edwin A. Davis, Plant Physiologist

Weed Control in Crops Section

Crops Protection Research Branch

Crops Research Division

Agricultural Research Service

United States Department of Agriculture

Located at Arizona State University, Tempe, Arizona

in cooperation with the

Rocky Mountain Forest and Range Experiment Station

U. S. Forest Service

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SUMMARY

CR f1-18. The general optimum growth conditions for turbinella oak were established: hot days (above 90°F) with partial shade (3,000 f.c.) and warm nights (above 70°F).

A study of the growth pattern of turbinella oak showed that most seedlings grew intermittently in definite rhythmic patterns. Not all seedlings had the same growth pattern; and their rate of growth varied greatly. Growth during the night and day proceeded at the same rate. Growth was not limited by seasonal changes in photoperiod but continued on short days under warm conditions. These results are of value in growing plants for experimental purposes and they provide a basis for a study of the relation between stage of growth and susceptibility to herbicide control.

CR f1-14 (C). Soil applications of herbicides represent a promising approach for the control of chaparral. Seven herbicides were evaluated on turbinella oak in the greenhouse and their persistence and leaching characteristics were studied. Fenuron gave excellent control and was the most effective chemical. 2,3,6-TBA was also very effective, although slower-acting.

CR f1-15. Explanations for the lack of effectiveness of soil applications of simazine on turbinella oak were investigated. It was found that turbinella oak is not only protected physically because of simazine's resistance to leaching but that it is also physiologically tolerant to simazine.

CR f1-17. In an investigation of the relation between control of turbinella oak in the field with seven soil-applied herbicides and a posttreatment irrigation with 0, 1, 2, and 4 inches of water, fenuron proved to be the most effective herbicide. The response of turbinella oak to fenuron without irrigation was slight, but with 1-4 inches of water initial injury was greatly increased. The major shift in effectiveness occurred between the 0-1 inch irrigation levels.

CR f1-14 (C). The order of initial foliar toxicity of three phenoxy herbicides on turbinella oak with the most active first was: 2,4,5-T, silvex, and 2,4-D.

The volume of spray application of 2,4-D from 10-160 gpa at high chemical rates had little effect on herbicide toxicity; but at low chemical rates the volume of application had an appreciable effect.

Thirty-four substituted benzoic acids were evaluated as foliar sprays on turbinella oak. The most active of these chemicals were: 2-methoxy-3,6-dichlorobenzoic acid; 2,3,5,6-tetrachlorobenzoic acid; 2,3,6-TBA; and PBA. The foliar toxicity of these chemicals is considerably less than that of 2,4,5-T but they are of interest because of their stunting action.

Thirteen s-triazines were evaluated as foliar sprays on turbinella oak. Sprayed in water, they were all without effect; but sprayed in Deobase, several were highly active. None, however, prevented regrowth.

FOREWARD

The investigations included in this report are part of a broad cooperative national research program which has as its objective the development of principles, methods, and practices of brush control. More specifically, the investigations are being conducted for the purpose of developing methods of controlling Arizona chaparral. The chemical control of chaparral vegetation is one aspect of the research program being conducted by the U. S. Department of Agriculture to determine the influence of vegetation manipulation on water yield and forage production. The work was conducted by personnel in the Crops Protection Research Branch, Crops Research Division, Agricultural Research Service, at Tempe, Arizona, in cooperation with the U. S. Forest Service. Research facilities were provided by the Rocky Mountain Forest and Range Experiment Station at Arizona State University, Tempe, Arizona.

The investigations included in this report represent mainly the laboratory and greenhouse phase of the chaparral control project. The investigations are restricted to Quercus turbinella (turbinella oak) which is the chief problem shrub in the Arizona chaparral complex.

Introduction

An understanding of the growth of turbinella oak is important not only from the standpoint of providing optimum conditions for the growth of experimental plants but also because of the relation that may exist between plant growth and herbicide effectiveness. Several studies have been conducted with turbinella oak which define the general environmental conditions necessary for optimum plant growth, the seasonal, monthly, and diurnal growth patterns of greenhouse-grown plants, and the variations which exist between plants grown from seed.

Line Project No CR f1-18

General Environmental Conditions for the Optimum Growth Growth of Turbinella Oak (Exp 2-1-8)

Background

The laboratory and greenhouse program for the control of turbinella oak requires the growth of large numbers of plants. For this reason it is important to establish the general environmental conditions necessary for optimum plant growth

Objectives

1. To define the general daytime conditions for optimum growth of turbinella oak.

2. To determine the influence of night temperature on the growth of turbinella oak.

Materials and Methods

The influence of daytime conditions.--Turbinella oak seedlings were grown in a 50-50 peat-perlite mixture and in vermiculite contained in 46-ounce cans. When the plants were about 3 cm tall the seedlings in each medium were divided into four groups with each group containing 58 plants, 20 in the peat-perlite mixture and 38 in vermiculite. The night conditions for all groups were the same, but the day conditions were varied. The average minimum night temperature was 61°F. The general daytime conditions, which are characterized by average maximum temperatures and light intensities, were as follows: hot-shady, 97°F, 2,800 f.c.; hot-sunny, 97°F, 10,000 f.c.; warm-shady, 88°F, 2,000 f.c.; and cool-sunny, 76°F, 12,000 f.c. The plants under hot and warm regimes were in the greenhouses while the plants exposed to cool conditions were outside.

Each morning between 8 and 9 am the groups were moved to their respective locations and between 5 and 6 pm they were returned to a common greenhouse location.

The plants were watered regularly with Hoagland s nutrient solution and occasionally with distilled water.

The influence of night temperature.--Two groups of 55 plants each were subjected to different night temperatures (73°F and 78°F) and a common daytime condition (hot-shady, 99°F, 3,000 f.c.). The experiment was started on June 22, 1959, and final growth measurements were made on July 27, 1959. The plants were grown in a peat-perlite mixture and in vermiculite and were watered with Hoagland's nutrient solution.

Results

The results indicate that turbinella oak thrives under hot conditions with partial shade (Fig. 1). Hot-sunny conditions are slightly less favorable whereas warm-shady and cool-sunny conditions are considerably poorer. It was also observed that temperatures in excess of 100°F with full sun reduced growth drastically. However, many turbinella oak seedlings withstand excessive summer heat and full sun, provided that they have enough moisture.

The peat-perlite mixture was considerably superior to vermiculite as a long-term growth medium for turbinella oak. Previous studies also showed it to be superior for rooting turbinella oak cuttings.

The results of the night temperature experiment indicate that turbinella oak prefers warm nights (Table 1). This finding has been substantiated by observations made on the growth of turbinella oak during cool winter months.

These results supply information needed for growing turbinella oak for experimental purposes; and they are in general agreement with the observation that at lower elevations, where temperatures are high and moisture may be a limiting factor, turbinella oak tends to be more abundant on north-facing slopes while at higher elevations it is denser on south-facing slopes.

Table 1.--The influence of night temperature on the growth of turbinella oak grown under hot-shady daytime conditions.1/

Averate temperature (°F)		Average height growth (Cm) 36 days2/
Minimum night	Maximum day	
73	99	8.7
78	99	13.0

1/ Light intensity: 3,000 f.c. maximum.
2/ Average of 55 plants for each condition.

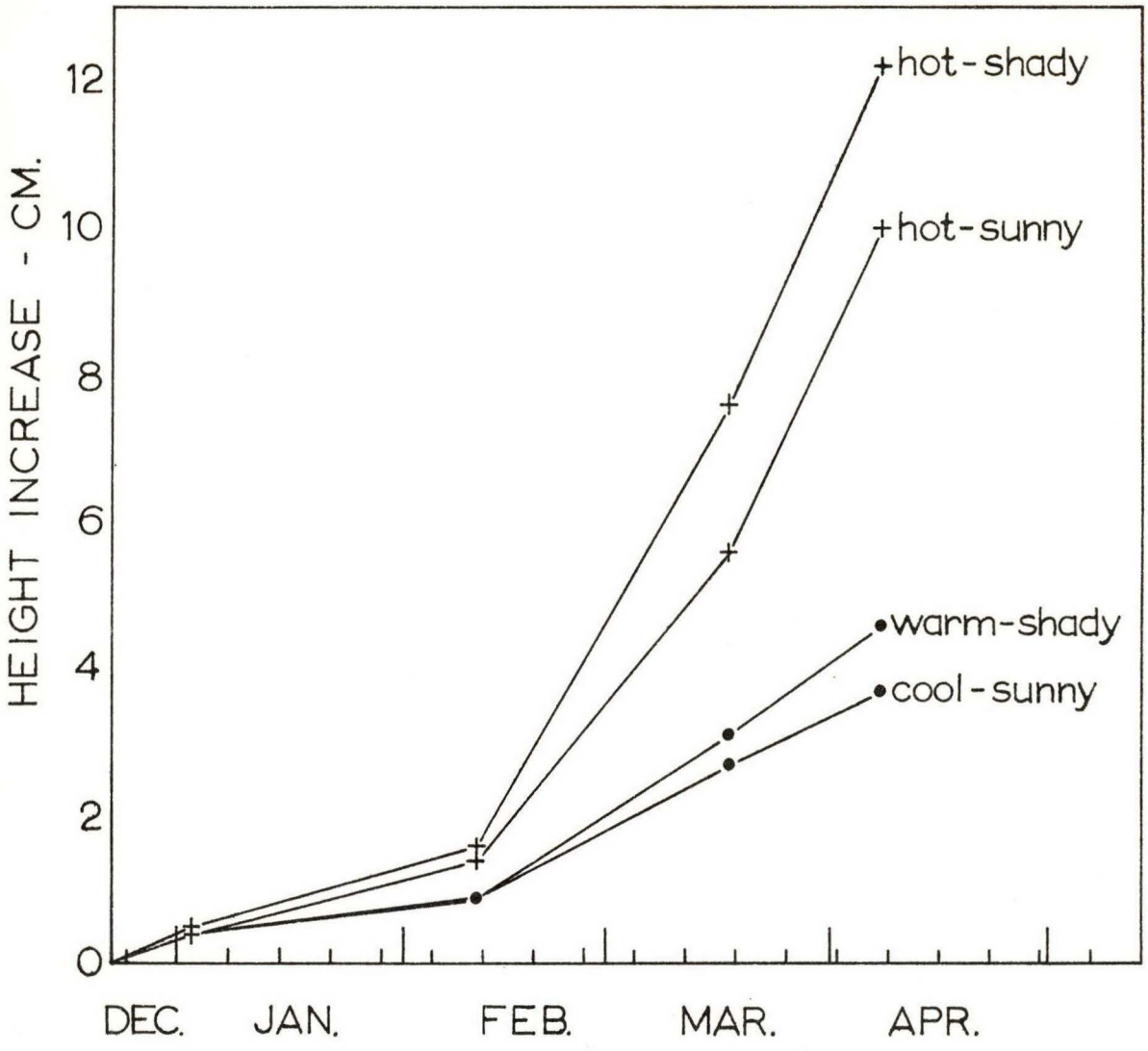


Figure 1.-- Growth of turbinella oak under various environmental conditions. Night conditions were the same for all experiments; the average minimum night temperature was 61°F. The general daytime conditions listed in the graph are characterized by the following average maximum temperatures and light intensities: hot-shady, 97°F, 2,800 f.c.; hot-sunny, 97°F, 10,000 f.c.; warm-shady, 88°F, 2,000 f.c.; and cool-sunny, 76°F, 12,000 f.c.

The Growth Pattern of Turbinella Oak (Exp. 2-1-15)

Background

Casual observations of the growth of turbinella oak indicated that its growth in height occurred intermittently or in flushes. This type of growth has been observed for a number of woody species including loblolly pine, eastern red oak, tea, and many tropical trees. In the field, this pattern of intermittent growth has often been attributed to environmental factors--but with studies conducted under constant environmental conditions this cannot be the explanation. The interval between flushes during which growth ceases or slows down may be caused by the accumulation of an inhibitor or the exhaustion of some essential factor and may be considered as a type of semi-dormancy.

The rhythmic growth pattern of turbinella oak was investigated because of the possible relation which exists between stage of plant growth and susceptibility to control by herbicides.

Objectives

1. The trace the rhythmic growth pattern of turbinella oak grown under greenhouse conditions.

2. To determine the influence of the diurnal-nocturnal cycle on the growth of turbinella oak.

3. To determine the effect of seasonal changes on the growth and rhythmic pattern of turbinella oak.

Materials and Methods

In order to trace the rhythmic growth pattern of turbinella oak, daily height measurements were made on a group of 27 plants growing in a 50-50 peat-perlite mixture contained in 46-ounce cans. The moisture and the nutrient content of the medium were maintained at an adequate level by frequent irrigations with one-half strength Hoagland's nutrient solution; environmental conditions of light and temperature were adequate for growth.

The influence of the diurnal-nocturnal cycle on growth was studied by measuring plant height before and after the night period.

Seasonal effects on growth and rhythmic pattern under greenhouse conditions were studied by making daily height measurements from May through December.

Results

Rhythmic growth pattern.--The majority of turbinella oak plants possessed a definite rhythmic growth pattern characterized by periods of rapid growth separated by intervals of various length during which growth ceased or slowed down markedly (Fig. 2). Most of the plants exhibited definite growth cycles such as those for plants Nos. 6 and 15. Plants with this type of growth formed a terminal bud after each flush of growth. For slow-growing plants, the interval between flushes was usually longer than normal while the length of the growth periods was shorter than normal. The fastest growing plants, such as plant No. 27, grew continuously for long periods of time during which growth proceeded in a definite rhythmic pattern but never stopped entirely.

The growth rate and pattern of the plants varied greatly and are apparently regulated by internal factors. Not all plants grew at the same time; nor did all branches on an individual plant necessarily grow in unison.

The detailed growth pattern of turbinella oak in the field has not yet been studied but fewer flushes are produced. Changes in plant growth are timed with major changes in moisture and temperature; and many details of the potential growth patterns are undoubtedly masked by the plants' responses to major environmental fluctuations.

The influence of the diurnal-nocturnal cycle on growth.--The influence of day and night periods on the growth of turbinella oak was studied with plants which were in their growth phase. It was found that the plants grew in height both during the day and night with essentially no difference in growth rate (Table 2).

Table 2.--Day and night growth of turbinella oak (Exp. 2-1-15)

Condition	Hours	Height growth increase 1/	
	Average	Cm	Cm/Hr
Day	9.4	0.65	0.069
Night	14.6	1.09	0.075

1/ Average of 10 measurements.

Seasonal effects on growth.--The growth of turbinella oak in the greenhouse with adequate temperatures for growth was independent of seasonal changes of photoperiod (Table 3).

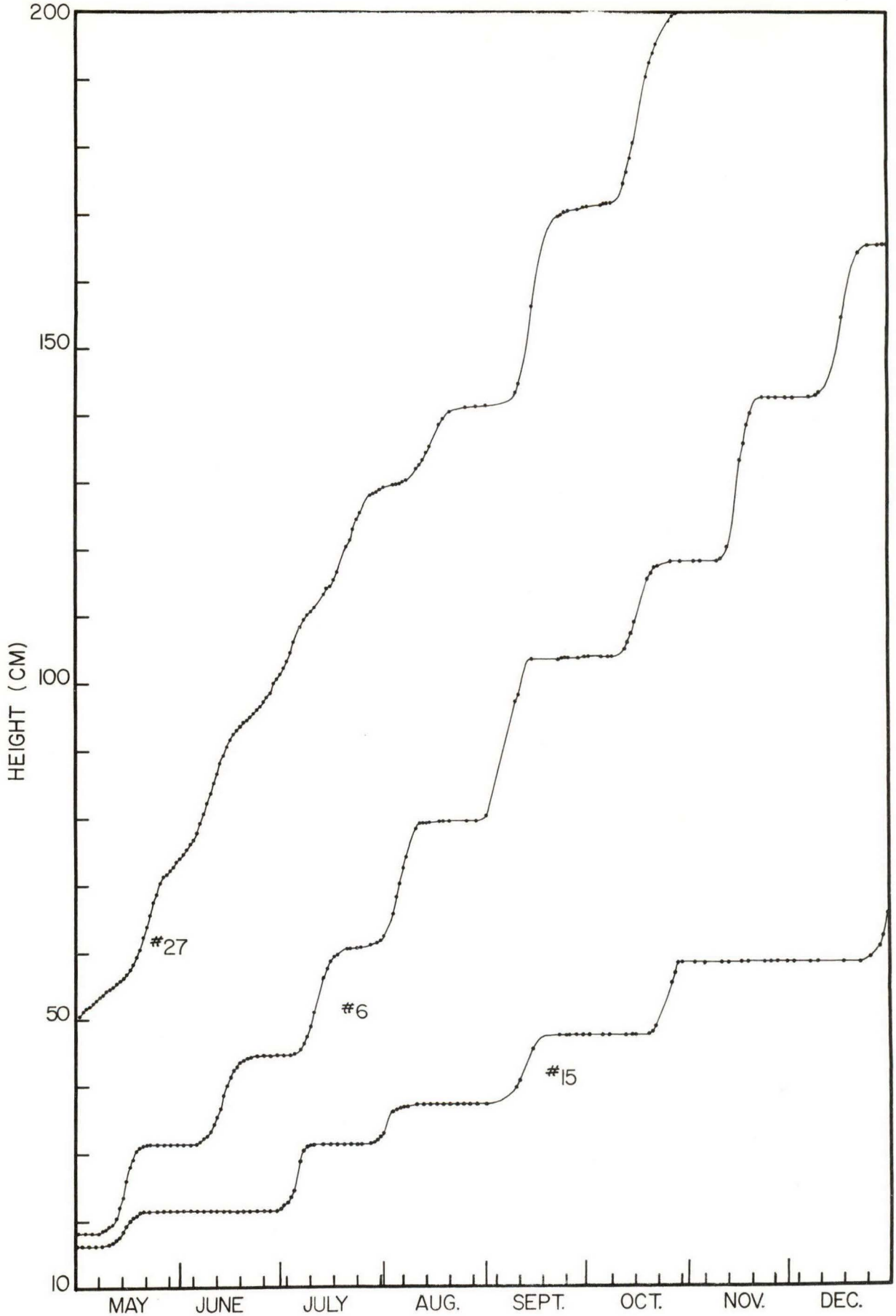


Figure 2.-- Height growth of turbinella oak illustrating the rhythmic growth patterns.

Table 3.--Monthly growth of turbinella oak in the greenhouse for 8 months from May through December 1959.

Month	Height growth increase[1/]
	Cm.
May	10.7
June	12.2
July	13.9
August	12.3
September	13.0
October	15.6
November	11.3
December	14.3

1/ Average of 23 plants.

Although the growth of turbinella oak is not limited by photoperiod during the fall and winter, it is readily limited by temperature. Growth has been observed to slow down markedly or to stop entirely with night temperatures of 50°-55°F. The lag period in growth noted in figure 1 may be due to limiting night temperatures during the first part of the experiment.

Variability in growth.--There is great variability in the growth of turbinella oak seedlings. Considering the 23 plants whose growth patterns were studied, the slowest growing plant grew only 24.5 cm. in eight months while the fastest growing plant grew 191.7 cm. The growth of this group of plants, with a measure of the degree of variability is summarized in table 4.

Table 4.--Statistics of height growth increase from 23 turbinella oak plants over an 8 month period, from May-December.

Mean (Cm)	103.2
Standard deviation (Cm)	44.87
Coefficient of variation (percent)	43.5

Undoubtedly there is also tremendous variability in the growth potential of turbinella oak in the field; and part of the variability of control with herbicides both in the greenhouse and in the field may be due to the variability in growth.

SOIL HERBICIDE INVESTIGATIONS

Introduction

Due to the fact that foliar herbicide sprays have not adequately controlled turbinella oak, partly because of the inability of such treatments to prevent regrowth and sprouting, there is a need for an exploration of other methods of controlling this species by chemical means. Soil applications of pelleted or granular herbicides offer a possible practical method of controlling turbinella oak by killing top growth and preventing or killing subsequent sprouts. Pelleted or granular herbicides can be applied conveniently either by hand-broadcasting, by ground equipment, or by aerial application.

Some of the factors which affect the results of soil-applied herbicides are: rainfall, soil type and composition, water solubility of the chemical, adsorption of the chemical on soil particles, chemical and microbial decomposition, volatility, and photodecomposition.

Line Project CR f1-14(c)

The Evaluation of Several Soil-Applied Herbicides For the Control of Turbinella Oak (Exp. 4-1-1)

Background

By evaluating soil-applied herbicides in the greenhouse, adequate conditions can be provided for the expression of chemical activity. In the following study, a group of pelleted and granular herbicides were evaluated under greenhouse conditions for the control of turbinella oak.

Objectives

1. To evaluate several soil-applied herbicides, formulated as pellets or granules, for the control of turbinella oak.

2. To determine the persistence of the herbicides in soil.

3. To determine the leaching characteristics of the herbicides in soil

Materials and Methods

Experimental plant material consisted of three-month-old turbinella oak seedlings grown in gallon cans containing a loamy-sand top soil

obtained from a chaparral area in Dewey, Arizona The mechanical analysis of the soil was as follows: coarse sand, 47.1%; fine sand, 31.3%; silt, 13.8%; clay, 7.8%.

Pelleted and granular herbicides were scattered uniformly on the soil at rates of 2, 4, 8, and 16 lbs. active ingredient per acre. At the low rates the pellets and granules were ground in order to obtain a uniform distribution on the soil The following herbicides were evaluated:

Chemical	Designation	Formulation	Percent Active Ingredient
3-(p-chlorophenyl)-1,1-dimethylurea	Monuron	pellets	25
3-phenyl-1,1-dimethylurea	Fenuron	pellets	25
3-(p-chlorophenyl)-1,1-dimethylurea trichloroacetate	Urox	granules	22
2,3,6-trichlorobenzoic acid	2,3,6-TBA	granules	25
2-chloro-4,6-bis(ethylamino)-s-triazine	Simazine	granules	8.5
2,4-dichlorophenoxyacetic acid, butoxy ethanol ester	2,4-D ester	granules	10
2,4,5-trichlorophenoxyacetic acid butoxy ethanol ester	2,4,5-T ester	granules	10
2-(2,4,5-trichlorophenoxy)propionic acid, butoxy ethanol ester	Silvex ester	granules	10

Each treatment unit consisted of two, one-gallon cans of turbinella oak containing a total of 12-20 seedlings. Treatments were applied on December 31, 1959.

After the chemicals were applied the soil in each can was irrigated with $\frac{1}{4}$ inch of distilled water. Thereafter, known amounts of distilled water or one-half strength Hoagland's solution were applied regularly to maintain adequate moisture and nutrients for growth and to leach the herbicides into the soil. During the experiment the soil was irrigated with a total of 54.5 inches of water added in $\frac{1}{4}$, $\frac{1}{2}$, and 1 inch increments.

Top injury of the seedlings was estimated visually; and percentage of plants killed was calculated from plant count data.

Persistence of the herbicides in the soil was determined from the response of radish and oat seedlings grown in the cans with the oak.

Distribution pattern of the herbicides in the soil was determined nine months after treatment. The soil in the cans was removed in one-inch layers and the herbicidal activity of the soil layers was determined from the growth response of radishes and oats.

Results

Plant injury and kill.--The seedlings responded very slowly to the herbicides (Table 5). Five weeks after application only slight injury symptoms were apparent. At this time monuron appeared to stimulate growth. The plants seemed greener, lusher, and in general healthier than untreated controls. As time passed, however, typical monuron symptoms developed. After nine weeks the effects of the herbicides were more pronounced, but were still incomplete; injury was greatest with fenuron. After twenty weeks the results of the study were fairly clear although the effects of all of the chemicals still were not final (Fig 3). A quantitative evaluation of the herbicides in terms of plant kill is given in table 6. Clearly, fenuron was the most effective herbicide evaluated for the control of turbinella oak in this experiment. Not only was it the fastest acting herbicide, but in terms of plant kill after nine months it was not exceeded by any of the other herbicides. The superiority of fenuron over monuron probably is due largely to its greater water solubility; the solubility of fenuron is 2,900 ppm while that of monuron is 230 ppm. Also, fenuron is less readily absorbed on soil particles than monuron.

The final effect of monuron-TCA (Urox) was slightly superior to that of monuron alone. This is of interest since the amount of monuron in the monuron-TCA treatments was about 50 percent less than the amount of monuron in the straight monuron treatments.

The general pattern of injury with monuron, fenuron, and monuron-TCA was the same. Initial injury symptoms were characterized by marginal necrosis of the leaves similar to leaf burn, with a gradual extension of the injury until the entire leaf was dead. Stem tissue was not killed initially and healthy new leaves developed. After the new leaves expanded they frequently developed interveinal chlorosis and marginal leaf injury and finally died. This process might have been repeated several times before the plant was killed.

The final kill by 2,3,6-TBA was similar to that by monuron, but the striking effect of 2,3,6-TBA was one of stunting. For many weeks rates as low as 2 lbs. per acre inhibited growth completely. Branching was profuse as the result of injured terminal buds and the developing shoots were severely malformed (Fig. 4). Normal leaves did not begin to appear until six months after treatment. Even after nine months the surviving plants in the 4-16 lb. treatments were 88-98 percent inhibited. At this time bio-assays of the 2,3,6-TBA treated soil showed only negligible amounts of 2,3,6-TBA.

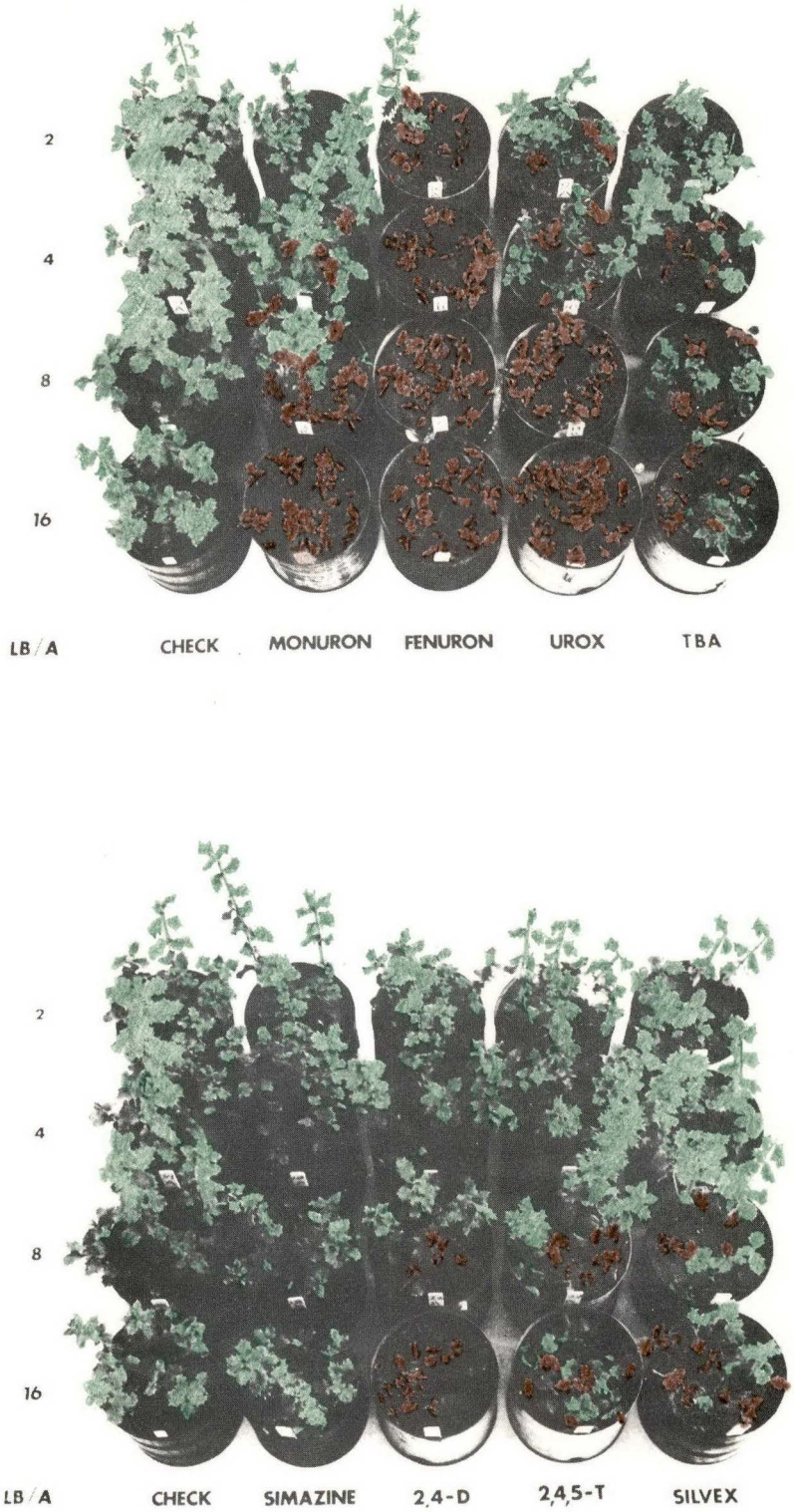


Figure 3.-- Influence of soil applications of several granular and pelleted herbicides on turbinella oak seedlings 20 weeks after treatment. Total of 17.5 inches of water were applied in ¼ - 1 inch increments.

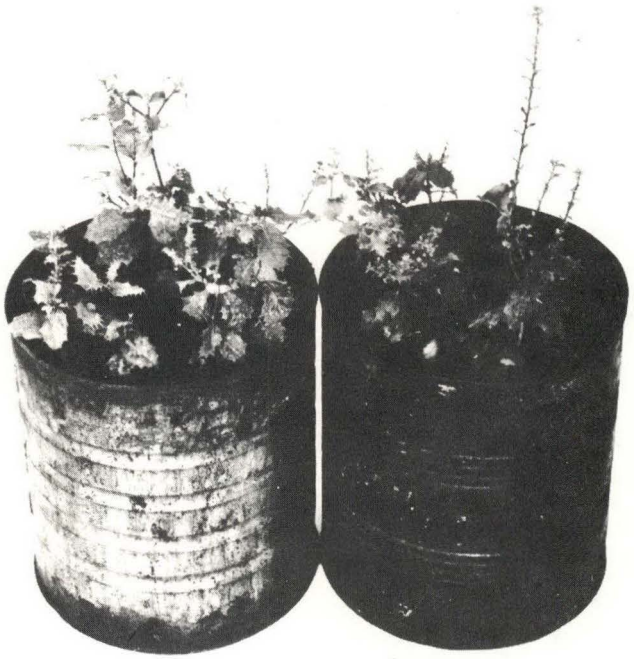


Figure 4.-- Malformation of turbinella oak seedlings 22 weeks after a granular application of 2,3,6-TBA at the rate of 2 lb active ingredient per acre.

Herbicide persistence in soil.--The persistence of the herbicides in the soil can be judged on the basis of the data in table 7 and 8. Simazine, monuron, and monuron-TCA were the most persistent herbicides in the experiment and continued to show high activity after six months. Fenuron was considerably less persistent than monuron or monuron-TCA. 2,3,6-TBA was less persistent than fenuron. The butoxy ethanol ester of 2,4-D was the least persistent herbicide tested. It failed to show any activity seven weeks after treatment. The butoxy ethanol ester of silvex was more persistent than the butoxy ethanol ester of 2,4,5-T; silvex had the same order of persistence as fenuron.

Herbicide distribution pattern in the soil.--At the completion of the experiment with turbinella oak, mine months after the application of the herbicides, the vertical distribution of the herbicides in the soil was studied (Table 8). Monuron and monuron-TCA were still present in inhibitory amounts and were fairly well distributed through the soil column, but showed a definite gradient from the top to the bottom of the can. The two herbicides showed nearly identical activities and distribution patterns. Very little fenuron was detected at any soil depth. 2,3,6-TBA was not detected in herbicidal amounts at any soil depth although the indicator plants showed slight malformation symptoms. Very little 2,4,5-T remained at any soil depth; the amount of silvex remaining was greater and it was distributed throughout the soil column. Simazine was the most residual herbicide evaluated. After nine months, it was still present in the top inch of soil, of the 2 lb to 16 lb per acre treatments, in quantities lethal to oats and radishes. It was extremely resistant to leaching.

Conclusions

On the basis of this investigation and the herbicides evaluated, fenuron offers the greatest promise for the control of turbinella oak. 2,3,6-trichlorobenzoic acid is also of particular interest. The persistence characteristics of these herbicides offers hope that grass establishment in the field may be possible after an appropriate period of time following their application. In nature, both the action of the herbicides on turbinella oak and their persistence in the soil, will be influenced by the amount of rainfall.

Table 5.--Top injury to turbinella oak in the greenhouse by several pelleted and granular herbicides[1/]

Herbicide	Lbs/Acre active ingredient	Top injury after--[2/] 5 weeks	9 weeks	20 weeks	26 weeks
		percent	percent	percent	percent
Monuron	2	0	2	30	25
	4	0	10	45	62
	8	0	25	50	95
	16	0	80	100	100
Fenuron	2	5	25	85	70
	4	35	85	100	100
	8	15	85	100	100
	16	20	95	100	100
Monuron-TCA (Urox)	2	0	20	55	50
	4	0	25	70	80
	8	0	20	100	100
	16	2	20	99	100
2,3,6-TBA	2	0	2	20	8
	4	10	10	68	78
	8	5	30	72	88
	16	5	40	78	88
Simazine	2	0	2	0	0
	4	0	0	0	2
	8	5	10	10	8
	16	0	2	10	12
2,4-D ester	2	5	0	0	0
	4	10	30	20	12
	8	20	50	52	40
	16	15	80	100	100
2,4,5-T ester	2	5	0	0	0
	4	5	5	45	45
	8	10	40	52	35
	16	15	50	85	85
Silvex ester	2	5	5	10	2
	4	5	5	35	25
	8	2	20	48	45
	16	2	45	88	88

1/ Soil treated December 31, 1958.
2/ Top injury rated on February 4, 1959; March 4, 1959, May 20, 1959; and July 1, 1959.

Table 6.--Kill of turbinella oak in the greenhouse by several pelleted and granular herbicides[1/]

Herbicide	Lbs/Acre active ingredient	Plants killed after--[2/] 20 weeks	6 months	9 months
		percent	percent	percent
Monuron	2	40	55	55
	4	43	48	55
	8	84	94	94
	16	100	100	100
Fenuron	2	76	76	76
	4	100	100	100
	8	100	100	100
	16	100	100	100
Monuron-TCA (Urox)	2	56	76	76
	4	56	75	81
	8	96	100	100
	16	80	100	100
2,3,6-TBA	2	18	24	30
	4	60	66	76
	8	80	80	90
	16	72	72	96
Simazine	2	27	27	27
	4	0	7	7
	8	28	34	40
	16	11	22	33
2,4-D ester	2	44	44	44
	4	50	50	55
	8	66	66	66
	16	100	100	100
2,4,5-T ester	2	32	32	32
	4	46	46	51
	8	70	70	70
	16	86	86	86
Silvex ester	2	44	44	44
	4	58	58	58
	8	56	67	72
	16	72	78	100

1/ Soil treated December 31, 1959.
2/ Number of plants killed determined on July 1, 1959 and September 30, 1959.

Table 7.--Persistence of herbicidal activity in soil treated for the control of turbinella oak.

Herbicide	Lbs/Acre active ingredient	Herbicidal activity[1] Initial	after seven weeks[2]	after six months[3]	Average herbicidal activity of all dosages after 6 months
Monuron	2	100	92	86	96
	4	100	92	100	
	8	100	100	100	
	16	100	100	100	
Fenuron	2	100	64	33	50
	4	100	91	32	
	8	100	100	48	
	16	100	100	88	
Monuron-TCA (Urox)	2	100	92	70	86
	4	100	100	73	
	8	100	100	100	
	16	100	100	100	
2,3,6-TBA	2	94	43	0	20
	4	99	80	6	
	8	100	98	10	
	16	100	100	64	
Simazine	2	100	-	98	99
	4	100	100	100	
	8	100	100	100	
	16	100	100	100	
2,4-D ester	2	100	0	0	0
	4	100	0	0	
	8	100	0	0	
	16	100	0	0	
2,4,5-T ester	2	100	34	0	14
	4	100	54	0	
	8	100	78	0	
	16	100	96	54	
Silvex ester	2	100	62	34	60
	4	100	90	33	
	8	100	96	72	
	16	100	96	100	

1/ Herbicidal activity is expressed as percent growth reduction of oats and radishes used as indicator plants. 0=no activity. 100=high activity.
2/ After seven weeks a total of 5 inches of water had been applied.
3/ After six months a total of 26.5 inches of water had been applied.

Table 8.--Herbicide distribution pattern in the soil nine months after treatment[1/]

Herbicide	Lbs/Acre active ingredient	Herbicidal activity of indicated layers of soil[2/] 0-1 inch	1-2 inch	2-3 inch	3-4 inch	4-5 inch	5-6 inch
Monuron	2	32	28	24	18	8	4
	4	47	30	32	22	18	5
	8	82	66	50	34	28	27
	16	100	96	95	94	96	98
Fenuron	4	0	1	20	12	2	6
	8	0	8	15	18	14	6
	16	6	13	21	22	23	6
Monuron-TCA (Urox)	2	34	24	27	28	14	6
	4	52	40	33	31	21	14
	8	70	64	58	54	49	49
	16	100	92	91	82	78	82
2,3,6-TBA	4	0	1	9	3	0	0
	8	0	0	3	0	0	0
	16	0	5	0	4	6	0
Simazine	2	100	18	2	4	2	0
	4	100	54	27	8	0	0
	8	100	94	84	80	64	28
	16	100	100	100	100	98	32
2,4,5-T ester	16	0	4	8	22	20	8
Silvex ester	16	56	28	26	16	20	32

1/ All treatments received a total of 54.5 inches of water during the nine month period.

2/ Herbicidal activity is expressed as percent growth reduction of oats and radishes used as indicator plants: 0=no activity; 100=high activity.

An Investigation of Possible Reasons for the Ineffectiveness of Soil Applications of Simazine On Turbinella Oak (Exps. 4-1-1, 4-1-2, and 5-1-1)

Background

Since simazine is a potent herbicide for a wide variety of plants, the reason for its ineffectiveness as a soil application for the control of turbinella oak is of interest. The lack of control of turbinella oak by simazine is not surprising, however, since simazine is recommended for weed control in nursery stock. Nevertheless, questions which arise are -- is simazine ineffective against turbinella oak because it is not leached into the root zone, or is turbinella oak tolerant to simazine? An examination of the root system of turbinella oak grown in gallon cans showed that most of the roots were localized in the bottom inch of soil. The tap root grows straight to the bottom of the can and then continues to grow in circles, forming a mat of roots in the bottom inch of soil. If the ineffectiveness of soil applications of simazine for the control of turbinella oak is because of physical protection then there would be definite encouragement for a study of other s-triazines. The following studies were conducted to answer the questions raised.

Objectives

1. To determine the distribution pattern of simazine in soil treated with simazine for the control of turbinella oak in gallon cans.

2. To determine the sensitivity of turbinella oak to subsoil applications of simazine in close contact with the roots.

3. To determine the sensitivity of nutrient solution cultures of turbinella oak to simazine in the nutrient solution.

Materials and Methods

Distribution pattern of simazine in soil.--The distribution pattern of simazine in soil treated for the control of turbinella oak in gallon cans was determined by removing the soil from the cans in one-inch layers and testing the soil for herbicidal activity by means of the indicator plants oats and radishes. This study was performed in conjunction with the soil-herbicide evaluation experiment previously described in which a total of 54.5 inches of water had been applied during the nine-month experimental period.

Subsoil applications of simazine.--The bottoms of gallon cans of vigorous year-old turbinella oak plants were opened and the cans were placed directly on other gallon cans full of soil, the surface of which had been treated individually with simazine at rates of 8 and 16 lbs. per acre and monuron and fenuron at 8 lbs. per acre. This brought the roots into contact with the herbicides. The cans were taped together

and were then watered regularly with distilled or one-half strength Hoagland's solution in $\frac{1}{4}$ inch and $\frac{1}{2}$ inch increments. Controls without herbicide applications were treated similarly. Monuron and fenuron were included to test the response of the oak plants to standard herbicide treatments and to compare the effectiveness of monuron and fenuron when the factor of soil penetration was eliminated.

Nutrient solution culture test with simazine.--Turbinella oak seedlings 7-12 inches tall, but pruned to about seven inches for uniformity, were removed from soil and transferred to Hoagland's nutrient solution in quart jars. The solutions contained individual treatments of 0.008-125 ppm simazine and fenuron. Each treatment was run in duplicate. Fenuron was included as a standard herbicide treatment. Tomato (var. Early Pak) and cotton (Acala 444) plants were tested in similar solutions in order to establish the phytotoxicity of the solutions. Air was bubbled through the solutions continuously.

Results

The distribution pattern of simazine in soil treated for the control of turbinella oak in gallon cans indicated that simazine probably was not leached in toxic amounts to the bottom inch of soil which contained the bulk of the root system (Table 8). At the 2 and 4 lb. per acre rates most of the simazine was located in the top inch of soil. At the 8 and 16 lb. per acre rates the herbicide penetrated to greater soil depths but was present in very low amounts in the bottom inch of soil. This indicates that turbinella oak is protected physically against simazine by virtue of simazine's extreme resistance to leaching.

The subsoil application experiment demonstrated that simazine at 8 and 16 lbs. per acre was ineffective against turbinella oak even though the simazine was placed in close contact with the mat of roots. Similar treatments with monuron and fenuron at 8 lbs. per acre caused 70 percent injury after 10 weeks. Soil surface treatments of monuron are generally much slower acting than fenuron but in this experiment in which the factor of soil penetration was eliminated they acted with the same speed.

The nutrient solution experiment demonstrated that turbinella oak is tolerant to simazine (Table 9). Oak plants grew without injury in solutions containing as much as 125 ppm simazine; the solubility of simazine in water is only 5 ppm. The phytotoxicity of the simazine solutions was established by the response of tomato and cotton plants which were injured by concentrations of 0.04 ppm and 0.2 ppm respectively. The susceptibility of the oak plants to fenuron, included as a standard herbicide treatment, also was established; concentrations of 5 ppm and higher were lethal. The lethal threshold concentration for fenuron was between 1 and 5 ppm.

Conclusions

It is concluded that turbinella oak is physiologically tolerant to simazine. It is not known if this tolerance results from an enzymatic destruction of simazine within the plant, such as occurs in corn, or from lack of absorption by the roots. In addition to turbinella oak's tolerance to simazine it is also protected physically by virtue of simazine's extreme resistance to leaching.

Table 9.--The influence of simazine and fenuron in the nutrient solution on nutrient cultures of tomato, cotton, and turbinella oak plants.

Herbicide	Conc.	Top injury to--		
		Tomato[1/]	Cotton[1/]	Turbinella oak[2/]
	ppm	percent	percent	percent
Simazine	0.008	0	0	0
	0.04	77	0	0
	0.2	99	49	0
	1	100	100	0
	5	100	100	0
	25	-	-	0
	125	--	-	0
Fenuron	0.008	0	0	0
	0.04	56	0	0
	0.2	96	0	0
	1	100	84	10
	5	100	99	100
	25	-	-	100
	125	-	-	100

1/ Percent reduction of tops after 28 days.

2/ Percent injury to turbinella oak after 61 days.

The Effectiveness of Soil-Herbicide Irrigation Treatments For the Control of Turbinella Oak in the Field (Exp. 4-2-1)

Technical Personnel

E. A. Davis and D. T. Lillie

Background

In nature the leaching of soil-applied herbicides into the root zone of turbinella oak depends on rainfall It is desirable, therefore, to have a knowledge of the relation between rainfall and the response of turbinella oak to soil-applied herbicides. In addition, the potential activity of chemicals can be evaluated with greater certainty if they are irrigated into the soil rather than left on the soil surface to be leached by chance rainfall.

Objectives

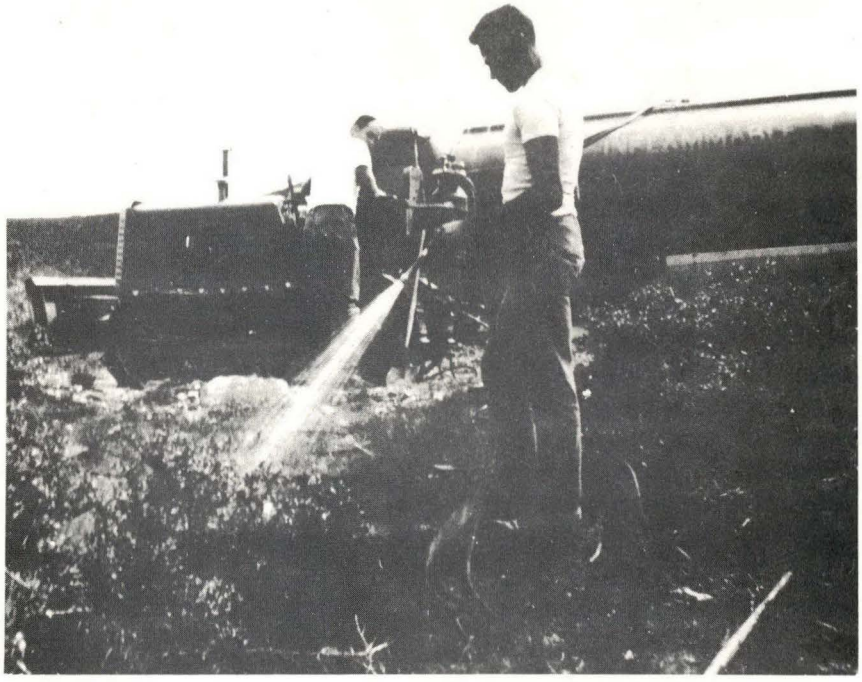
1. To determine the effectiveness of soil applications of several pelleted and granular herbicides on turbinella oak in the field.

2. To determine the effects of irrigating soil-herbicide applications into the soil with various amounts of water, on the control of turbinella oak.

Materials and Methods

Galvanized sheet metal frames were used to form 16-square foot basins around individual trubinella oak bushes and were banked with soil in order to hold water. The herbicide treatments were scattered uniformly on the soil within the frames and were irrigated into the soil with 1, 2, and 4 inches of water.

Water was pumped from a 3,000-gallon capacity tank truck by a pump on the power take-off of an Oliver OC-4 crawler tractor and was sprayed onto the plots (Fig. 5). The quantity of water applied was measured with a water meter.



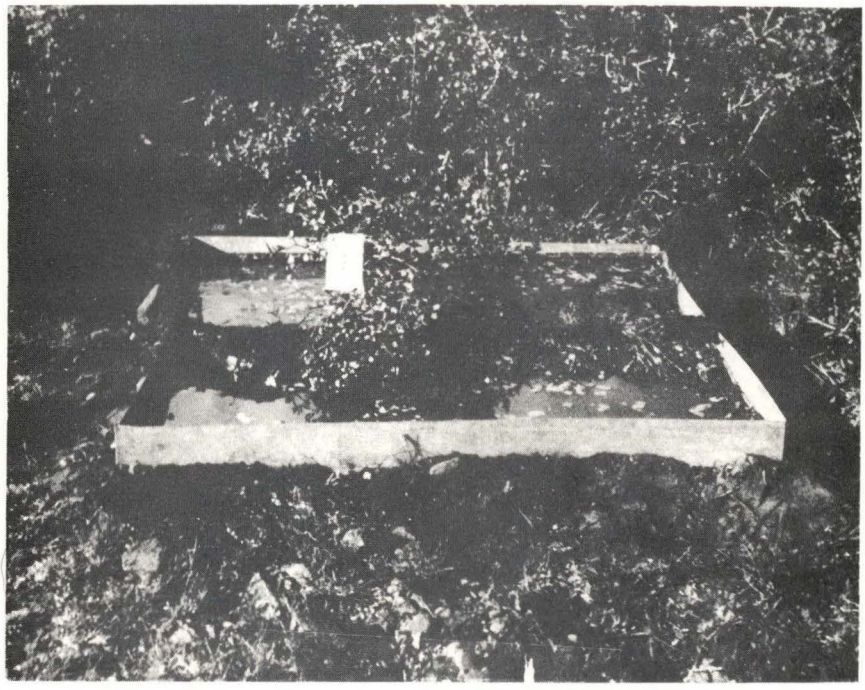


Figure 5.-- (Top) The application of water to individual turbinella oak bushes treated with soil-applied herbicides. (Bottom) 16 sq. ft. irrigation basin formed by a galvanized sheet metal frame.

The following chemicals were tested:

Chemical	Designation	Formulation	Percent active ingredient
3-(p-chlorophenyl)-1,1-dimethylurea	monuron	pellets	25
3-phenyl-1,1-dimethylurea	fenuron	pellets	25
3-(p-chlorophenyl)-1,1-dimethylurea trichloroacetate	Urox	granules	22
2,3,6-trichlorobenzoic acid	2,3,6-TBA	granules	25
2,3,6-trichlorophenylacetic acid	Fenac	granules	10
2-chloro-4,6-bis(ethylamino)-s-triazine	simazine	granules	8.5
2,4-dichlorophenoxyacetic acid, butoxy ethanol ester	2,4-D ester	granules	10
2-(2,4,5-trichlorophenoxy)propionic acid, butoxy ethanol ester	silvex ester	granules	10

Each chemical was applied at three rates (4, 8, and 16 lbs/A or 8, 16, and 32 lbs/A) with each rate tested at three irrigation levels, and without irrigation. Chemically untreated controls also received 0-4 inches of water. There were three replicates for each treatment, making a total of 264 plots. Treatments were applied from August 18-25, 1959.

A rain gage was set up in the experimental area to provide a record of rainfall. The experimental area was located in the Prescott National Forest, Poland Junction, Arizona.

Results

One and three months after treatment fenuron showed the greatest activity of the chemicals tested (Table 10). Without an irrigation treatment, it failed to cause severe injury (maximum of 52%); but with irrigations of 1-4 inches of water it caused moderate to severe leaf injury (70-90%) at the 8 and 16 lb. per acre rates. The 4 lb. per acre treatments showed only minor effects after three months. There was very little difference in the response of turbinella oak to fenuron with 1-4 inch irrigations, although the greatest injury occurred at the highest irrigation level. Plant response to the fenuron irrigation treatments was very rapid as seen by the effect of the chemical one month after treatment.

Table 10.--The effectiveness of soil-herbicide irrigation treatments for the control of turbinella oak in the field[1]/

Herbicide	Lbs/Acre active ingredient	Inches of water							
		0	1	2	4	0	1	2	4
		Percent leaf injury after one month[2]/				Percent leaf injury after three months[3]/			
Monuron	4	0	0	0	0	1	0	0	0
	8	0	2	0	7	1	2	0	7
	16	0	0	3	15	0	0	5	20
Fenuron	4	3	7	10	27	7	8	10	27
	8	13	65	67	68	19	72	74	74
	16	30	63	62	85	52	71	90	98
Urox	4	0	0	0	0	0	0	0	0
	8	0	0	0	0	5	0	0	0
	16	0	27	7	25	0	31	10	33
2,3,6-TBA	4	37	2	0	5	43	2	2	5
	8	2	2	0	0	2	2	0	0
	16	12	17	15	2	25	22	45	1
Fenac	4	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	2	5	0
	16	0	0	0	0	2	4	0	0
2,4-D ester	8	0	5	0	0	0	0	0	0
	16	0	0	0	0	3	0	0	0
	32	2	0	2	3	5	0	0	2
Silvex ester	8	0	0	0	2	0	0	0	0
	16	0	0	3	0	0	1	0	0
	32	0	3	0	0	2	0	2	0

1/ Treatments applied August 25, 1959.

2/ September 25, 1959.

3/ November 20, 1959.

Plant response to 2,3,6-TBA was slight and erratic; the highest incidence of leaf injury was 45 percent. It was the second most active chemical in the experiment.

Monuron and Urox caused very little injury; Urox was slightly superior to monuron. This is in agreement with greenhouse studies. The effects of fenac, 2,4-D, and silvex were negligible.

These results are preliminary; additional time is required before the final effects of the chemicals can be evaluated. The findings at the present time are in general agreement with the results of greenhouse tests.

Conclusions

On the basis of observations made one and three months after treatment it is concluded that fenuron is the fastest acting and most effective of the herbicides evaluated in this experiment. The initial response of turbinella oak to fenuron without irrigation was slight, but with 1-4 inches of water initial injury was greatly increased. The major shift in effectiveness occurred between the 0-1 inch irrigation levels.

FOLIAR HERBICIDE INVESTIGATIONS

Introduction

Foliar herbicide investigations with turbinella oak are being conducted in the greenhouse for the purpose of improving upon the control that can be obtained with 2,4,5-T and silvex. Single applications of these chemicals in the field have failed to give adequate control due to their inability to prevent regrowth. Some success has been achieved with repeated applications. But there is need either for an improvement in the efficacy of single applications of 2,4,5-T or silvex--or for superior chemicals.

Spray Equipment

For purposes of evaluating chemicals for the control of turbinella oak and for investigating methods of improving the action of 2,4,5-T and silvex, a laboratory turntable spray chamber was built. A photograph of the chamber is shown in figure 6. The turntable consists of a $\frac{1}{4}$-inch thick aluminum disc 14-inches in diameter. It is mounted on a rod which fits into a shaft supported by a bearing mounted underneath the bottom of the chamber. The height of the table can be adjusted by means of a pair of set-screws in the shaft. A 1/250 H.P., 25 rpm gear motor turns the shaft directly. An adjustable dual nozzle setup mounted on a rack consists of pneumatic atomizing nozzles manufactured by Spraying Systems Company. Air is supplied to the nozzles from a portable 1/3 H.P. compressor after passing through an air filter and a pressure regulator. An exhaust fan is located in the top of the chamber. The front of the chamber consists of an aluminum framed glass panel which can be raised and lowered. The bottom of the chamber slopes to a trough which slopes to a drainage outlet at one corner.

The spray chamber is calibrated to deliver volumes of solution equivalent to specific gallons per acre, by adjusting the volume of spray solution to give the correct amount of solution in six-inch petri dish lids rotated with the table at the normal height of treatment cans. The volume of solution collected in the dish is determined gravimetrically with a direct reading balance.

One of the conveniences of this chamber is that the spray solution is drawn out of open containers by the suction force of the atomizing air. It is convenient to accurately regulate the volume of spray application and chemical rate. This spray chamber was used for the investigations which follow.

Figure 6.-- Turntable spray chamber for evaluating foliar herbicides.

The Effects of Volume of Spray Application and Chemical Rate of Three Phenoxy Herbicides on Turbinella Oak (Exp. 3-1-1)

Background

Widespread applications of herbicides on rangelands and watersheds can most easily be accomplished with aerial equipment. Volumes of spray solution applied per acre in this manner are usually considerably lower than amounts sprayed by ground equipment. The observation is occasionally made that low-volume applications of highly concentrated spray solutions are not as effective as less concentrated high-volume sprays. The effect of spray volume and concentration is an important consideration in determining the practicality of a herbicidal chemical. Thus, a study was made to determine the effect of spray volume and concentration of three phenoxy herbicides on turbinella oak.

It was intended that the immediate benefits to be gained from this study would include: an evaluation of a low volatile ester of 2,4-D, 2,4,5-T, and silvex on turbinella oak seedlings; and a knowledge of the influence of spray volume and concentration on herbicide effectiveness, which would serve as a guide for future spray tests with turbinella oak.

Objectives

1. To evaluate the influence of spray volume and concentration of the propylene glycol butyl ether esters of 2,4-D, 2,4,5-T, and silvex on turbinella oak.

2. To compare the effectiveness of the herbicides mentioned above on turbinella oak.

Materials and Methods

Plant material.--Plant material consisted of ten-month-old turbinella oak seedlings, grown from acorns in the greenhouse and contained in 46-ounce cans. The plants were 6-12 inches tall with basal stem diameters of 2-3 millimeters.

Spraying equipment.--Spraying was accomplished with a turntable spray chamber described previously and calibrated to deliver the desired volume of spray solution on the cans for the equivalence of specified gallons per acre. A dual nozzle setup consisted of the following pneumatic atomizing nozzles manufactured by the Spraying Systems Company: fluid nozzle 135100 and air nozzle 120432; fluid nozzle 2850 and air nozzle 73420

Chemicals and treatments.--Chemicals consisted of the propylene glycol butyl ether esters of 2,4-dichlorophenoxyacetic acid (2,4-D), 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), and 2-(2,4,5-trichlorophenoxy)propionic acid (silvex). The trade names of the

products used were Esteron 10-10, Esteron 245, and Kuron respectively. The herbicides were sprayed at rates of $\frac{1}{4}$, $\frac{1}{2}$, 1, 2, and 4 lbs. per acre; and each rate was sprayed at volumes of 10, 20, 40, 80, and 160 gallons per acre. The atomizing air pressure was 10 psi. Additional wetting agents were not added to the spray mixtures. A treatment unit consisted of two 46-ounce cans of turbinella oak containing a total of 2-5 plants.

Plant coverage and wetting.--At the lowest volume rate of 10 gpa, plant coverage and wetting were very poor. Improvement in leaf coverage occurred as the volume of spray solution was increased, but in no case were the leaves wet with a complete film of solution. Rather, the spray solution accumulated in droplets which developed in size as the volume of solution was increased.

Post-treatment of plants.--After the plants were sprayed they were placed outside under hot-shady conditions to dry, in order to reduce volatility effects in the greenhouse.

Environmental conditions during the experiment.--

Average minimum night temperature: 72°F (range, 63°-78°F)

Average maximum day temperature: 95°F (range, 84°-108°F)

Light intensity 2,000-3,000 f.c. maximum.

Date sprayed and length of observation period.--The plants were sprayed on August 10, 1959, and observations made on October 12, 1959, 63 days later. Top injury was complete at the time observations were made.

Results

With the propylene glycol butyl ether ester of 2,4-D at the rate of $\frac{1}{4}$ lb. active ingredient per acre, injury to turbinella oak seedlings was greater with a spray volume of 20 gpa than with a spray volume of 10 gpa (Table 11). Above 20 gpa there was no apparent improvement in herbicide effectiveness. At chemical rates of $\frac{1}{2}$ lb. per acre and higher there was not a marked difference in plant response as the volume of spray solution was increased.

The response of turbinella oak seedlings to 2,4,5-T and silvex as the propylene glycol butyl ether esters, was not greatly affected by the volume of spray solution from 10-160 gpa at chemical rates of $\frac{1}{4}$-4 lbs. per acre.

From the standpoint of foliar toxicity to turbinella oak seedlings, 2,4,5-T was slightly more effective than silvex which in turn was more effective than 2,4-D.

Conclusions

At high rates of the phenoxy herbicides the volume of spray solution does not have an appreciable effect on top injury of turbinella oak seedlings. At low chemical rates, however, the volume of spray solution may have an appreciable effect on initial herbicide toxicity.

The applicability of low volume sprays for the evaluation of phenoxy herbicides on turbinella oak has been demonstrated.

This study does not necessarily relate to the problem of spray volume and inhibition of regrowth.

Table 11.--The effect of volume of spray application and chemical rate of three phenoxy herbicides on turbinella oak seedlings[1/]

Herbicide	Lbs/Acre	Percent leaf injury at-- 10 gpa	20 gpa	40 gpa	80 gpa	160 gpa
2,4-D, PGBE[2/] ester	¼	5	85	44	71	46
	½	80	80	70	100	75
	1	80	100	95	100	100
	2	95	100	100	100	100
	4	100	100	100	100	100
2,4,5-T, PGBE ester	¼	100	100	98	100	100
	½	100	100	100	100	100
	1	100	100	100	100	100
	2	100	100	100	100	100
	4	100	100	100	100	100
Silvex, PGBE	¼	75	88	71	96	100
	½	95	100	100	100	100
	1	100	100	100	100	100
	2	100	100	100	100	100
	4	100	100	100	100	100

1/ Observations were made 63 days after treatment

2/ Propylene glycol butyl ether ester

A Comparison of the Activity of Foliar Sprays of Several Phenoxy Herbicides and Substituted Benzoic Acids On Turbinella Oak (Exp. 3-1-2)

Background

The phenoxy herbicides and the substituted benzoic acids are two groups of compounds which are active on turbinella oak. In this experiment the foliar spray activity of low volatile esters of 2,4-D, 2,4,5-T, and silvex, and the dimethylamine salts of polychlorobenzoic acid and 2,3,6-trichlorobenzoic acid were compared.

Objectives

1. To compare the foliar spray activity of the propylene glycol butyl ether esters of 2,4-D, 2,4,5-T, and silvex; and the dimethylamine salts of polychlorobenzoic acid and 2,3,6-trichlorobenzoic acid on turbinella oak.

2. To determine the lethal threshold rates of the above mentioned herbicides on potted turbinella oak plants.

Materials and Methods

Plant material.--Plant material consisted of year-old turbinella oak seedlings contained 46-ounce cans The plants were 8-14 inches tall with basal stem diameters of 3-5 mm. Many of the plants were pruned immediately prior to the experiment.

Spray equipment.--The turntable spray chamber was used and was calibrated to deliver spray solution on the surface of the treatment cans at a volume rate of 10 gpa. A dual nozzle setup consisted of the following pneumatic atomizing nozzles manufactured by Spraying Systems Company: fluid nozzle 35100 and air nozzle 120432; fluid nozzle 2850 and air nozzle 73420.

Chemicals and treatments.--The following herbicides were evaluated:

Chemical	Designation	Trade name
2,4-dichlorophenoxyacetic acid, propylene glycol butyl ether ester	2,4-D	Esteron 10-10
2,4,5-trichlorophenoxyacetic acid, propylene glycol butyl ether ester	2,4,5-T	Esteron 245
2-(2,4,5-trichlorophenoxy)propionic acid, propylene glycol butyl ether ester	silvex	Kuron
polychlorobenzoic acid, dimethylamine salt	PBA	Benzac 354
2,36-trichlorobenzoic acid, dimethylamine salt	2,3,6-TBA	Benzac 1281

Each chemical was sprayed at rates of 1/32, 1/16, 1/8, 1/4, 1/2, 1, and 2 lbs. per acre at a spray volume of 10 gpa with an atomizing air pressure of 10 psi. Additional wetting agent was not added to the spray mixtures.

Plant coverage and wetting.--Leaf coverage and wetting were poor due to the low volume application and also due to the fact that additional wetting agent was not added to the spray mixtures. The mixtures were sprayed as a finely atomized spray which was shown to be effective in previous tests.

Posttreatment of plants.--After the plants were sprayed they were placed outside in the shade where they were left for seven days. This was done to eliminate volatility effects on other plants in the greenhouse. Volatility injury was previously noted when the airing period was only for a few hours.

Environmental conditions.--

Average minimum temperature, 61°F (range 50-72°F)

Average maximum temperature, 87°F (range 70-104°F)

Date sprayed and duration of experiment.--The plants were sprayed on October 23, 1959, and were graded on January 14, 1960, 83 days later. Top injury was complete at the time observations were made; but regrowth ratings were not final.

Results

The herbicides can be listed in the following order of decreasing effectiveness with respect to foliar toxicity: 2,4,5-T, silvex, 2,4-D, and the dimethylamine salts of PBA or 2,3,6-TBA (Table 12).

2,4,5-T was required at the rate of $\frac{1}{2}$ lb. per acre to produce 95 percent leaf injury of year-old turbinella oak plants; silvex and 2,4-D were required at rates of 1-2 lbs. per acre. Although the phenoxy herbicides killed existing foliage the regrowth which developed was normal.

The dimethylamine salts of PBA and 2,3,6-TBA had very slight initial foliar toxicity. Neither herbicide at the rate of 2 lbs. per acre markedly injured existing foliage; but their effects were manifested in the severely malformed growth which developed subsequent to treatment. This malformation was similar to that which resulted from soil treatments of TBA (Fig. 4). The regrowth was characterized by spindly shoots with small malformed abortive leaves. The terminal was usually swollen and frequently died, but lateral shoots developed; these new shoots might also die, followed by the development of additional laterals.

The persistence of PBA and 2,3,6-TBA in turbinella oak is indicated by their continued malformation effects on new growth. Although the 2 lb. rate was not lethal to the plants in this experiment, higher rates may produce effective control. Because of their malformation and inhibition of regrowth these compounds are of definite interest.

Conclusions

It is concluded that the initial foliar toxicity of 2,4,5-T on turbinella oak is greater than that of silvex, which in turn is more toxic than 2,4-D. 2,3,6-TBA and PBA are considerably less active than the phenoxy herbicides from the standpoint of initial foliar toxicity -- but they are of interest because of their inhibiting effects.

The preliminary evaluation of other phenoxy herbicides, in comparison with 2,4,5-T and silvex, should be made in the range of ½-1 lb. per acre.

The preliminary evaluation of other substituted benzoic acids, in comparison with 2,3,6-TBA, should be made at rates of 2 lbs. per acre and higher.

Table 12.--A comparison of the activity of foliar sprays of several phenoxy herbicides and substituted benzoic acids on turbinella oak year-old seedlings[1]/

Lbs. per 10 gals. per acre (acid equiv.)	2,4-D[2]/		2,4,5-T[2]/		Silvex[2]/		PBA[3]/		2,3,6-TBA[4]/	
	% Leaf injury	% kill	% Leaf injury	% kill	% Leaf injury	% kill	% Leaf injury	% kill	% Leaf injury	% kill
1/32	0	0	0	0	0	0	0	0	0	0
1/16	0	0	5	0	5	0	0	0	0	0
1/8	2	0	20	0	0	0	0	0	0	0
1/4	2	0	25	0	25	0	0	0	5	0
1/2	15	0	95	0	60	0	0	0	0	0
1	70	0	98	33	75	0	0	0	0	0
2	100	33	100	0	95	33	5/5	0	5/5	0

1/ Observations made 83 days after plants were sprayed.
2/ As the propylene glycol butyl ether ester
3/ Polychlorobenzoic acid, dimethylamine salt
4/ 2,3,6-trichlorobenzoic acid, dimethylamine salt
5/ New growth of all PBA and TBA treatments was severely malformed.

An Evaluation of the Foliar Spray Activity of Thirty-Four Substituted Benzoic Acids On Turbinella Oak (Exp. 3-1-3)

Background

In general the substituted benzoic acids have been used with little success on woody plants in western United States. However, polychlorobenzoic acid (PBA), effective on juniper in Arizona, and 2,3,6-trichlorobenzoic acid (2,3,6-TBA) have shown activity against turbinella oak when applied either as a foliar spray or as a soil treatment. For this reason it is desirable to study other substituted benzoic acids for possible greater activity.

Objectives

1. To evaluate 34 substituted benzoic acids as foliar sprays on turbinella oak.

2. To evaluate the biological activity of the above chemicals on radish plants.

Materials and Methods

Vigorous year-old turbinella oak plants with basal stem diameters of 4-7 millimeters and trimmed to a height of 10-16 inches were sprayed in a turntable spray chamber at rates of 2 and 4 lbs acid equivalent per acre, at a volume of 40 gpa, with an atomizing air pressure of 10 psi. The chemicals tested are listed in Table 13. The chemicals were formulated in either a 50-50 acetone-distilled water mixture or in distilled water, both of which contained 0.1 percent Vatsol. Pneumatic atomizing nozzles (fluid nozzle 60100, air nozzle 122435 and fluid nozzle 40100, air nozzle 73420) which produced a coarser spray than those previously used were adopted in order to reduce the rapid evaporation of the acetone spray solutions.

Wetting of the plants was excellent -- the leaves being uniformly covered with a complete film of solution. After the plants were sprayed they were returned immediately to the greenhouse.

A treatment unit of turbinella oak consisted of two 46-ounce cans containing a total of 3-5 plants.

In order to judge the biological activity of the chemicals they were tested also on radish seedlings. Two cups of radish seedlings were included with each oak treatment unit.

The plants were sprayed on December 18, 1959, and rated for foliar injury and regrowth on January 25, 1960, 38 days later. The following temperatures prevailed during this period:

Average minimum temperature, 58°F (range, 50°-68°F)

Average maximum temperature, 83°F (range, 70°-94°F)

Results (Table 13)

The leaf injury ratings represent an accurate evaluation of the initial foliar toxicity of the chemicals. Those chemicals which showed the greatest initial foliar toxicity on turbinella oak are as follows:

2-methoxy-3,6-dichlorobenzoic acid
2,3,6-trichlorobenzoic acid
2,3,5,6-tetrachlorobenzoic acid
polychlorobenzoic acid

The activity of these chemicals varied considerably, depending upon formulation. The contact action of PBA (Benzac 94A) in Deobase was greater than that of any other substituted benzoic acid tested; regrowth was abundant, however, and was less malformed than that of many other treatments. Deobase itself was not toxic; but it apparently increased the initial toxicity of PBA. Since regrowth occurred with both 2-methoxy-3, 6-dichlorobenzoic acid and 2,3,5,6-tetrachlorobenzoic acid there is no indication that they offer any advantages over 2,3,6-TBA or PBA. Additional studies will be made, however, to determine this point.

Lack of regrowth in the absence of leaf injury is not considered to be significant at the present time since regrowth is frequently slow to develop in the absence of leaf injury. The result with 3-amino-1,2,4-triazole is a possible exception. New growth which has occurred is typically colorless and has withered after slight development. At the present time the 1:4 combination of amino-triazole and polychlorobenzoic acid at rates of 2 and 4 lbs. per acre does not appear to be superior to the separate components.

None of the substituted benzoic acids gave as effective results as 2,4,5-T at comparable rates.

The results presented reflect only the initial effects of the chemicals. Additional time will be required before the final effects of the active chemicals can be evaluated.

Conclusions

Among the substituted benzoic acids evaluated, 2-methoxy-3, 6-dichlorobenzoic acid and 2,3,5,6-tetrachlorobenzoic acid are the only chemicals other than the standards, 2,3,6-TBA and PBA, which showed substantial initial foliar spray activity on turbinella oak.

Table 13.--An evaluation of the foliar spray activity of a group of substituted benzoic acids on radishes and turbinella oak[1]/

Chemicals[3]/	Percent leaf injury				Regrowth[2]/	
	Radish		Turbinella oak		Turbinella oak	
	2 Lb/A	4 Lb/A	2 Lb/A	4 Lb/A	2 Lb/A	4 Lb/A
2-methoxy-3,5-dichlorobenzoic acid, dimethylamine salt	0	0	0	10	+	-
2-methoxy-3,6-dichlorobenzoic acid	100	100	50	85	+	+
2-methoxy-3,6-dichlorobenzoic acid, dimethylamine salt	100	100	20	85	+	+
2-methoxy-3,5,6-trichlorobenzoic acid	99	99	5	10	+	-
2-methoxy-3,5,6-trichlorobenzoic acid, dimethylamine salt	100	99	20	30	-	+
2-methyl-3,6-dichlorobenzoic acid, dimethylamine salt	96	98	5	25	-	+
polychlorobenzoic acid, sodium salt	99	99	10	10	+	+
polychlorobenzoic acid, potassium salt	99	99	35	10	+	+
polychlorobenzoic acid, monoethanolamine salt	100	99	20	20	+	+
polychlorobenzoic acid, diethanolamine salt	96	99	10	25	+	+
polychlorobenzoic acid, triethanolamine salt	95	95	20	15	+	+
Benzoic acid	0	0	0	0	+	+
2-chlorobenzoic acid	0	0	0	0	+	+
3-chlorobenzoic acid	0	0	0	0	+	+
4-chlorobenzoic acid	0	0	0	0	+	+
2,4-dichlorobenzoic acid	0	0	0	0	+	+
2,5-dichlorobenzoic acid	5	5	5	5	+	+
3,4-dichlorobenzoic acid	0	0	0	0	+	+
2,3,4-trichlorobenzoic acid	5	5	0	5	+	+
2,3,5-trichlorobenzoic acid	50	75	5	10	+	+
2,3,6-trichlorobenzoic acid	90	90	20	55	+	+
2,4,5-trichlorobenzoic acid	0	0	5	10	+	+
2,3,4,5-tetrachlorobenzoic acid	0	0	0	0	+	+
2,3,5,6-tetrachlorobenzoic acid	99	99	25	50	+	+
pentachlorobenzoic acid	10	20	0	0	+	+
2,5-dichloro-3-nitrobenzoic acid	5	30	0	0	+	+
2,3,5-triiodobenzoic acid, triethylamine salt (ACP M-917)	5	20	0	0	+	-
2,3,5,6-tetrachlorobenzoic acid, triethylamine salt (ACP M-918)	100	100	25	20	+	+
3-amino-2,5-dichlorobenzoic acid, triethylamine salt (Amoben M-729)	30	90	5	0	+	-
2,3,6-trichlorobenzoic acid, dimethylamine salt (Benzac 1281)	98	99	40	50	+	-
polychlorobenzoic acid, dimethylamine salt (Benzac 354)	98	100	55	40	+	-

Continued on page 39.

Table 13 (Continued)

Chemicals[3]	Percent leaf injury: Radish 2 Lb/A	Radish 4 Lb/A	Turbinella oak 2 Lb/A	Turbinella oak 4 Lb/A	Regrowth[2] turbinella oak 2 Lb/A	Regrowth[2] turbinella oak 4 Lb/A
polychlorobenzoic acid (Benzac 94A) in Deobase	99	100	95	95	+	+
amino-triazole + polychlorobenzoic acid, amine salt (1 lb. + 4 lbs/gal) -ACP M-329	98	100	20	40	+	+
3-amino-1,2,4-triazole (liquid formulation) ACP M-569	100	100	0	10	-	-
trichlorobenzoic acid, dimethylamine salt (Tryben 200)	96	96	50	95	+	+
2,4,5-trichlorophenoxyacetic acid, butoxy ethanol ester (Weedone 2,4,5-T)	100	100	100	100	-	-
2,4,5-trichlorophenoxyacetic acid, propylene glycol butyl ether ester (Esteron 245)	100	100	100	100	-	-

1/ Plants were sprayed on December 18, 1959, and rated on January 25, 1960, 38 days later.

2/ Regrowth is rated as present (+) or absent (-).

3/ All chemicals were tested on an acid equivalent basis at a spray volume of 40 gpa.

An Evaluation of the Foliar Spray Activity of Thirteen s-Triazines on Turbinella Oak (Exp. 3-1-4)

Background

Soil applications of simazine (2-chloro-4,6-bis(ethylamino)-s-triazine) as well as nutrient solution culture tests indicate that simazine is ineffective against turbinella oak. However, within the group of herbicidally active s-triazines there are compounds which are much more water soluble than simazine -- and there are a number of cases of herbicidal specificity. Consequently, it was considered prudent to evaluate the herbicidal s-triazines for their activity as foliar sprays on turbinella oak.

Tests with the benzoic acid herbicides indicated that the initial foliar spray activity of polychlorobenzoic acid was increased by the use of Deobase (purified kerosene) as the carrier. Doebase itself was found not to be toxic to turbinella oak. This suggests that the oil may have increased the absorption of the chemical by the leaves. Since leaf penetration may be the limiting factor for foliar activity of the s-triazines, both water and Deobase were used as carriers.

Objectives

1. To evaluate the foliar spray activity of thirteen s-triazines on turbinella oak.

2. Compare the effectiveness of water and Deobase as carriers for foliar sprays of the s-triazines on turbinella oak.

Materials and Methods

Vigorous year-old turbinella oak plants with basal stem diameters of 4-7 millimeters and trimmed to a height of 10-16 inches were sprayed in a turntable spray chamber with the chemicals listed in table 14. The chemicals were evaluated at the rate of 8 lbs. active ingredient per acre at a spray volume of 40 gpa with an atomizing air pressure of 10 psi. Each chemical was applied in water and in Deobase. The chemicals were obtained either as wettable powders or as emulsifiable concentrates. The water spray mixtures were prepared with water containing 0.1 percent Vatsol and they gave excellent wetting and coverage of the plants. The Deobase sprays also thoroughly wet the plants.

A treatment unit of turbinella oak consisted of two 46-ounce cans containing a total of 3-5 plants.

In order to judge the biological activity of the chemicals they were tested also on black mustard seedlings. Two cups of black mustard were included with each turbinella oak treatment unit.

The plants were sprayed on December 31, 1959, and were rated for foliar injury and regrowth on January 25, 1960, 25 days later. Temperatures during the experiment were as follows:

Average minimum temperature, 57°F (range, 50°-66°F)

Average maximum temperature, 84°F (range, 76°-94°F)

Results

None of the s-triazines were active on turbinella oak when water was used as the carrier. Leaf injury was minor and normal growth occurred following treatment in all cases (Table 14).

The initial foliar activity of all of the s-triazines was increased when Deobase was used as the carrier. Deobase itself was not toxic. Those chemicals which caused 90-100 percent leaf injury are as follows:

2-chloro-4-diethylamino-6-ethylamino-s-triazine (Trietazine)
2-chloro-4,6-bis(diethylamino)-s-triazine (Chlorazine)
2-methoxy-4,6-bis(isopropylamino)-s-triazine (Prometone)
2-methoxy-4-diethylamino-6-isopropylamino-s-triazine
2-chloro-4-diethylamino-6-isopropylamino-s-triazine
2-methoxy-4-ethylamino-6-isopropylamino-s-triazine

Regrowth occurred in all cases following the initial injury caused by these chemicals sprayed in Deobase.

All of the s-triazines in water and in Deobase gave 100 percent kill of black mustard seedlings.

Concludsions

On the basis of present observations it is concluded that none of the s-triazines are promising for the control of turbinella oak. Even though several of the chemicals caused severe leaf injury when they were sprayed in Deobase, they did not prevent regrowth. And unless the regrowth which developed dies, these chemicals will not be of practical value for the control of turbinella oak.

Table 14.--An evaluation of the foliar spray activity of 13 s-triazines on turbinella oak[1]/

(Application rate of 8 lb/A at 40 gpa)

Chemical	Designation	Water carrier: Leaf injury	Water carrier: Regrowth	Deobase carrier: Leaf injury	Deobase carrier: Regrowth
		percent		percent	
2-chloro-4,6-bis (ethylamino)-s-triazine	Simazine	0	+[2]/	5	+
2-chloro-4-ethylamino-6-isopropylamino-s-triazine	Atrazine	0	+	5	+
2-chloro-4-diethylamino-6-ethylamino-s-triazine	Trietazine	0	+	90	+
2-chloro-4,6-bis (isopropylamino)-s-triazine	Propazine	0	+	10	+
2-chloro-4,6-bis (diethylamino)-s-triazine	Chlorazine	5	+	95	+
2-methoxy-4,6-bis (ethylamino)-s-triazine	Simetone	0	+	60	+
2-methoxy-4,6-bis (isopropylamino)-s-triazine	Prometone	30	+	100	+
2-methoxy-4-diethylamino-6-isopropylamino-s-triazine		20	+	100	+
2-methoxy-4-methylamino-6-isopropylamino-s-triazine		5	+	50	+
2-methoxy-4-ethylamino-6-isopropylamino-s-triazine		5	+	90	+
2-chloro-4-propylamino-6-isopropylamino-s-triazine		0	+	40	+
2-chloro-4-methylamino-6-isopropylamino-s-triazine		10	+	30	+
2-chloro-4-diethylamino-6-isopropylamino-s-triazine		20	+	100	+

1/ Plants were sprayed on December 31, and they were rated on January 25, 1960, 25 days later.

2/ + indicates that regrowth occurred.

LIST OF HERBICIDES INCLUDED
IN THIS REPORT

Chemical	Designation	Formulation or Commercial trade name	Source[1/]
3-(p-chlorophenyl)-1,1-dimethylurea	Monuron	pellets	EID
3-phenyl-1,1-dimethylurea	Fenuron	pellets	EID
2,3,6-trichlorobenzoic acid	2,3,6-TBA	granules	EID
3-(p-chlorophenyl)-1,1-dimethylurea trichloroacetate	Urox	granules	GCD
2-chloro-4,6-bis(ethylamino)-s-triazine	Simazine	granules	GCC
2,4-dichlorophenoxyacetic acid, butoxy ethanol ester	2,4-D ester	granules	ACP
2,4,5-trichlorophenoxyacetic acid, butoxy ethanol ester	2,4,5-T ester	granules	ACP
2-(2,4,5-trichlorophenoxy)propionic acid, butoxy ethanol ester	Silvex ester	granules	ACP
2,3,6-trichlorophenylacetic acid	Fenac	granules	ACP
2,4-dichlorophenoxyacetic acid, propylene glycol butyl ether ester	2,4-D	Esteron 10-10	DCC
2,4,5-trichlorophenoxyacetic acid, propylene glycol butyl ether ester	2,4,5-T	Esteron 245	DCC
2-(2,4,5-trichlorophenoxy)propionic acid, propylene glycol butyl ether ester	Silvex	Kuron	DCC
2,4,5-trichlorophenoxyacetic acid, butoxy ethanol ester	2,4,5-T	Weedone 2,4,5-T	ACP
2,3,6-trichlorobenzoic acid, dimethylamine salt	2,3,6-TBA	Benzac 1281	ACP
polychlorobenzoic acid,dimethylamine salt	PBA	Benac 354	ACP
polychlorobenzoic acid (oil soluble)	PBA	Benac 94A	ACP
trichlorobenzoic acid, dimethylamine salt	2,3,6-TBA	Tryben 200	EID
2-methoxy-3,5-dichlorobenzoic acid, dimethylamine salt	-	-	VEL
2-methoxy-3,6-dichlorobenzoic acid	-	-	VEL
2-methoxy-3,6-dichlorobenzoic acid, dimethylamine salt	-	-	VEL
2-methoxy-3,5,6-trichlorobenzoic acid	-	-	VEL
2-methoxy-3,5,6-trichlorobenzoic acid, dimethylamine salt	-	-	VEL
2-methyl-3,6-dichlorobenzoic acid, dimethylamine salt	-	-	HEY
polychlorobenzoic acid, sodium salt	-	-	VEL
polychlorobenzoic acid, potassium salt	-	-	VEL
polychlorobenzoic acid, monoethanolamine salt	-	-	VEL
polychlorobenzoic acid, diethanolamine salt	-	-	VEL
polychlorobenzoic acid, triethanolamine salt	-	-	VEL

Continued on page 43.

Chemical	Designation	Formulation or Commercial trade name	Source[1/]
Benzoic acid	-	-	HCC
2-chlorobenzoic acid	-	-	HCC
3-chlorobenzoic acid	-	-	HCC
4-chlorobenzoic acid	-	-	HCC
2,4-dichlorobenzoic acid	-	-	HCC
2,5-dichlorobenzoic acid	-	-	HCC
3,4-dichlorobenzoic acid	-	-	HCC
2,3,4-trichlorobenzoic acid	-	-	HCC
2,3,5-trichlorobenzoic acid	-	-	HCC
2,3,6-trichlorobenzoic acid	-	-	HCC
2,4,5-trichlorobenzoic acid	-	-	HCC
2,3,4,5-tetrachlorobenzoic acid	-	-	HCC
2,3,5,6-tetrachlorobenzoic acid	-	-	HCC
pentachlorobenzoic acid	-	-	HCC
2,5-dichloro-3-nitrobenzoic acid	-	-	ACP
2,3,5-triiodobenzoic acid, triethylamine salt	-	ACP M-917	ACP
2,3,5,6-tetrachlorobenzoic acid, triethylamine salt	-	ACP M-918	ACP
3-amino-2,5-dichlorobenzoic acid, triethylamine salt	-	Amoben M-729	ACP
amino-triazole + polychlorobenzoic acid, amine salt (1 lb. + 4 lb./gal)	-	ACP M-329	ACP
3-amino-1,2,4-triazole, (liquid formulation)	-	ACP M-569	ACP
2-chloro-4,6-bis(ethylamino)-s-triazine	Simazine	-	GCC
2-chloro-4-ethylamino-6-isopropylamino-s-triazine	Atrazine	-	GCC
2-chloro-4-diethylamino-6-ethylamino-s-triazine	Trietazine	-	GCC
2-chloro-4,6-bis(isopropylamino)-s-triazine	Propazine	-	GCC
2-chloro-4,6-bis(diethylamino)-s-triazine	Chlorazine	-	GCC
2-methoxy-4,6-bis(ethylamino)-s-triazine	Simetone	-	GCC
2-methoxy-4,6-bis(isopropylamino)-s-triazine	Prometone	-	GCC
2-methoxy-4-diethylamino-6-isopropylamino-s-triazine	-	-	GCC
2-methoxy-4-methylamino-6-isopropylamino-s-triazine	-	-	GCC
2-methoxy-4-ethylamino-6-isopropylamino-s-triazine	-	-	GCC
2-chloro-4-propylamino-6-isopropylamino-s-triazine	-	-	GCC
2-chloro-4-methylamino-6-isopropylamino-s-triazine	-	-	GCC
2-chloro-4-diethylamino-6-isopropylamino-s-triazine	-	-	GCC

1/ Abbreviations on page

1/ Abbreviations

ACP	Amchem Products, Inc.
DCC	Dow Chemical Company
EID	E. I. duPont deNemours and Company
GCC	Geigy Chemical Corporation
GCD	General Chemical Division, Allied Chemical and Dye
HCC	Hooker Chemical Corporation
HEY	Heyden Newport Chemical Corporation
VCC	Velsicol Chemical Corporation

APPENDIX

1. Attendance at Meetings:

Western Weed Control Conference, Salt Lake City, March 17-20, 1959

Annual Meeting of Arizona Water Resources Committee, September 21, 1959.

2. Lectures Delivered:

Delivered a lecture and conducted three laboratory class periods for the Weed Control Course at Arizona State University.

ACKNOWLEDGEMENTS

Grateful acknowledgement is given to the following chemical companies which supplied chemicals for these investigations: American Cyanamid Company; Amchem Products, Inc.; Dow Chemical Company; Geigy Chemcial Corporation; General Chemical Division, Allied Chemical and Dye; Heyden Newport Chemical Company; Hooker Chemical Corporation; and Velsicol Chemical Corporation.

Appreciation is expressed also to the following: Dr. W C. Shaw and Mr. W. A. Gentner, U.S.D.A., Beltsville, Maryland, and Mr. Thomas N. Johnsen, Jr. U.S.D.A., Flagstaff, Arizona, for supplying samples of chemicals; Dr. Daniel Robinson, Arizona State University, for loaning the tank truck; Mr. Robert H. Hilgerman, University of Arizona, Citrus Experiment Station, Tempe, Arizona, for loaning the water meter.